



Vacuum Chamber R&D for SXFEL Undulator

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Contents

1

Overview

2

Specifications

3

Undulator Chamber Prototype

4

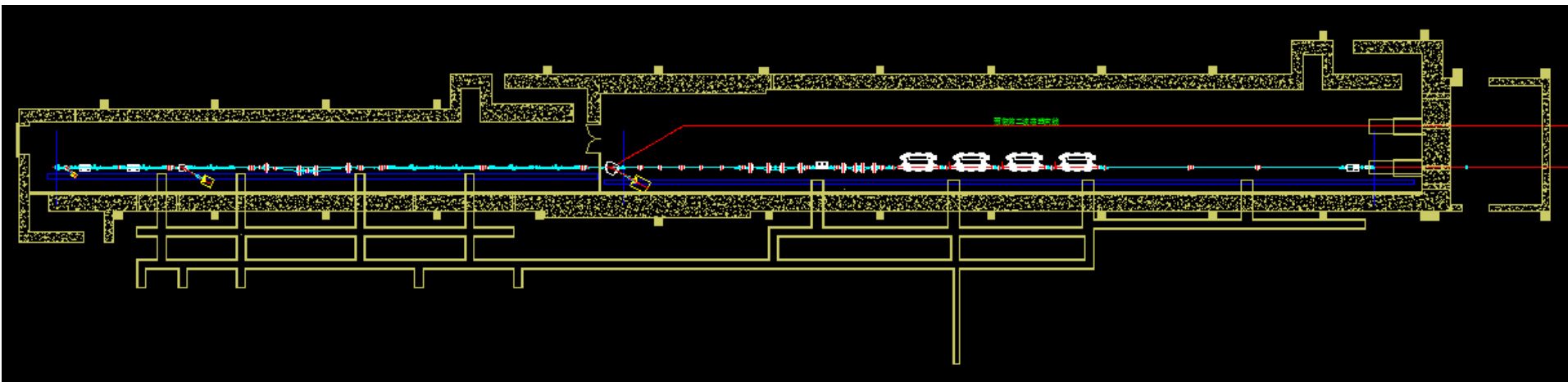
Vacuum Test

5

Summary

Overview

- ◆ The upcoming construction of Shanghai Soft X-ray Free Electron Laser Facility (SXFEL) and Dalian Coherent Light Source (DCLS) will use more than ten meters small gap undulators.
- ◆ Each undulator is 3 meters long and will work at a minimum gap of 9 mm.



SXFEL/DCLS Undulator Chamber

Specifications

2

Both oxygen-free copper and aluminum alloy vacuum chambers were designed and two prototypes were developed, respectively. Both of the chambers include three parts, copper or aluminum pipe, two flanges and a set of supports. Both copper and aluminum chamber pipes are manufactured by stretching.

- Long elliptical pipe stretching
- Long chamber brazing
- Inner surface polishing

Undulator Chamber		
Inner aperture (mm ²)	6×15	5X11
Thickness (mm)	0.75	0.5
Material	OFHC	Al 6063
Length (m)	3.2	3.2
Pressure (Pa)	<10 ⁻⁵	<10 ⁻⁵
Roughness (Ra)	<300nm	<300nm

Undulator Chamber Prototype

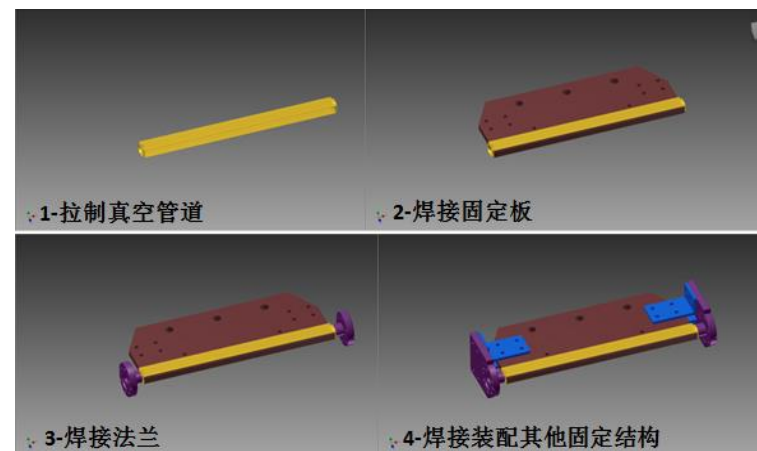
OFHC Prototype



Stretch Copper Pipe



Braze Flanges and supports

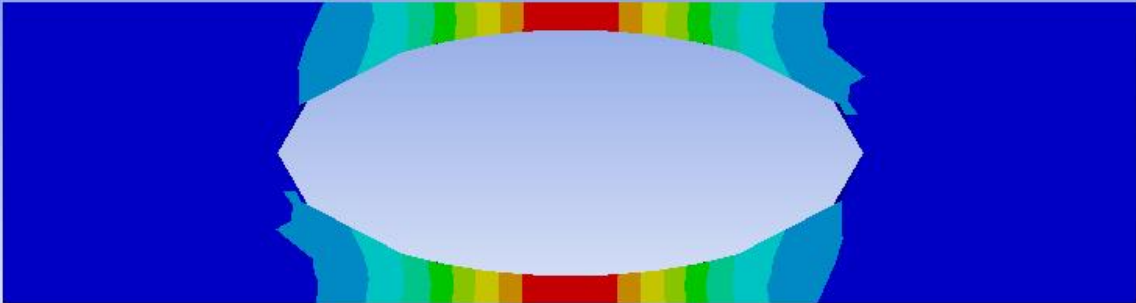
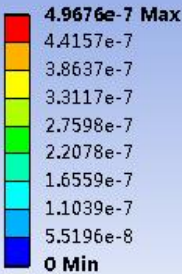


Undulator Chamber Prototype

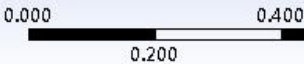
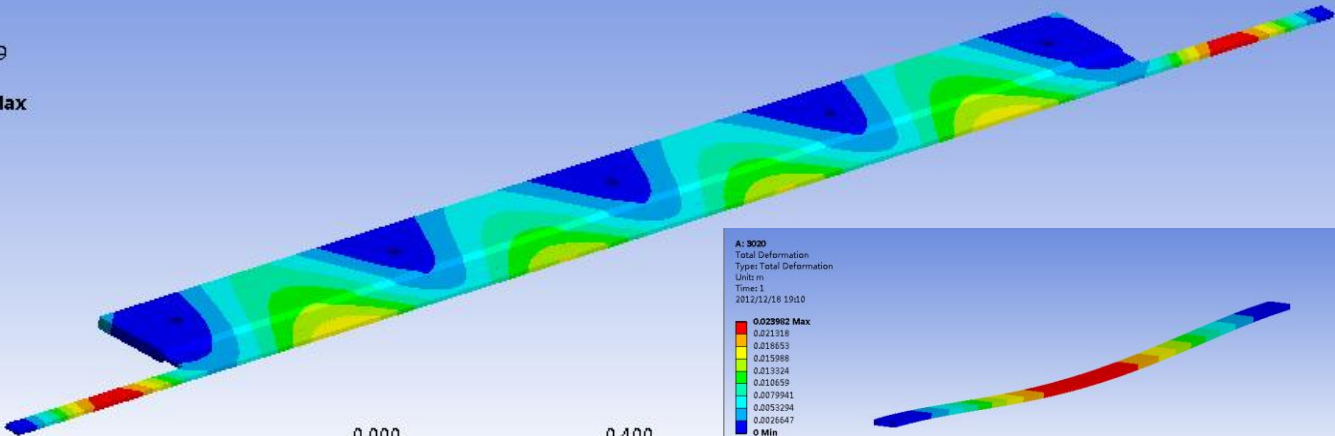
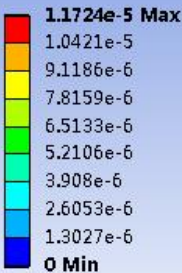
OFHC Prototype

ANSYS
v12

Total Deformation
Type: Total Deformation
Unit: m
Time: 1
2012/12/18 19:19



C: Static Structural (ANSYS)
Total Deformation
Type: Total Deformation
Unit: m
Time: 1
2012/12/18 19:09



Undulator Chamber Prototype

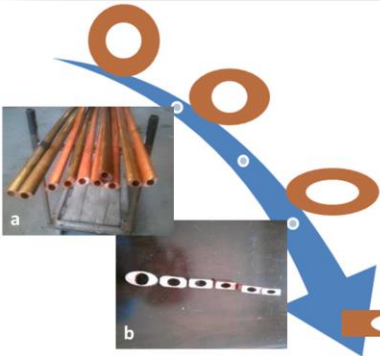
OFHC Prototype



Material	OFHC
Inner aperture (mm ²)	6×15
Thickness (mm)	0.75
Length (m)	3.27

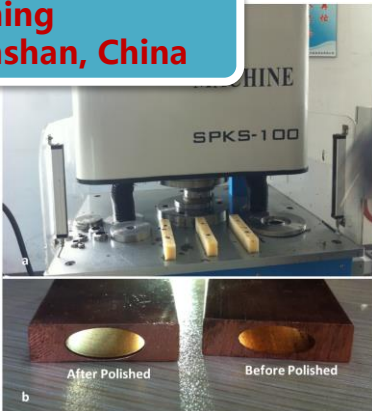


Brazing
@Beijing, China



Copper chamber
Stretching
@Shanghai, China

Polishing
@Kunshan, China



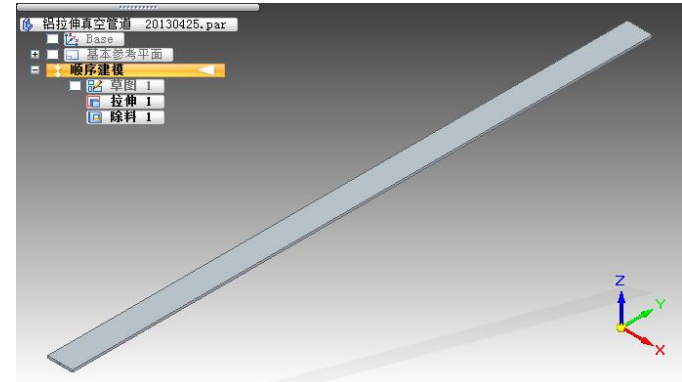
Undulator Chamber Prototype

Aluminum Prototype

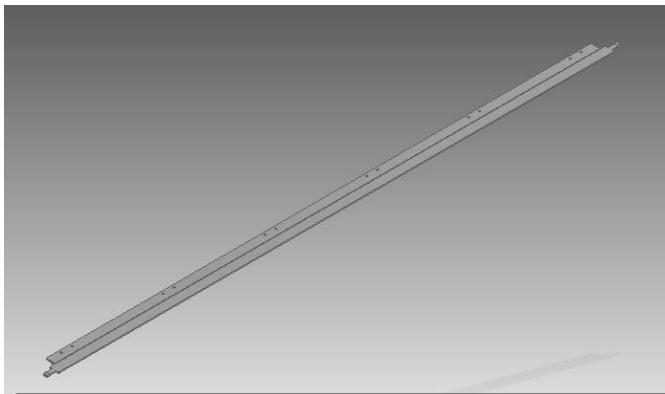
Parameters

Aperture	5mm × 11mm	
Height	6mm	
Min. Thickness	0.5mm	
Length	3270mm	
Material	Chamber	Aluminum Alloy
	Flanges	SS316L-AI5053 Clad Metal
	Support	SS

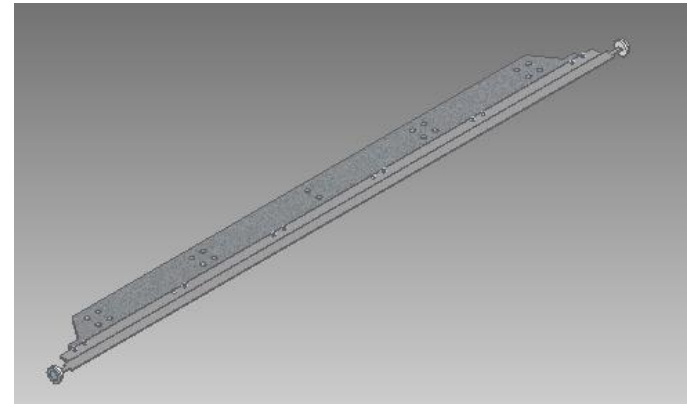
Process



1、Stretch Al Chamber



2、CNC Machine Al Chamber



3、Weld Flanges and Connect Support

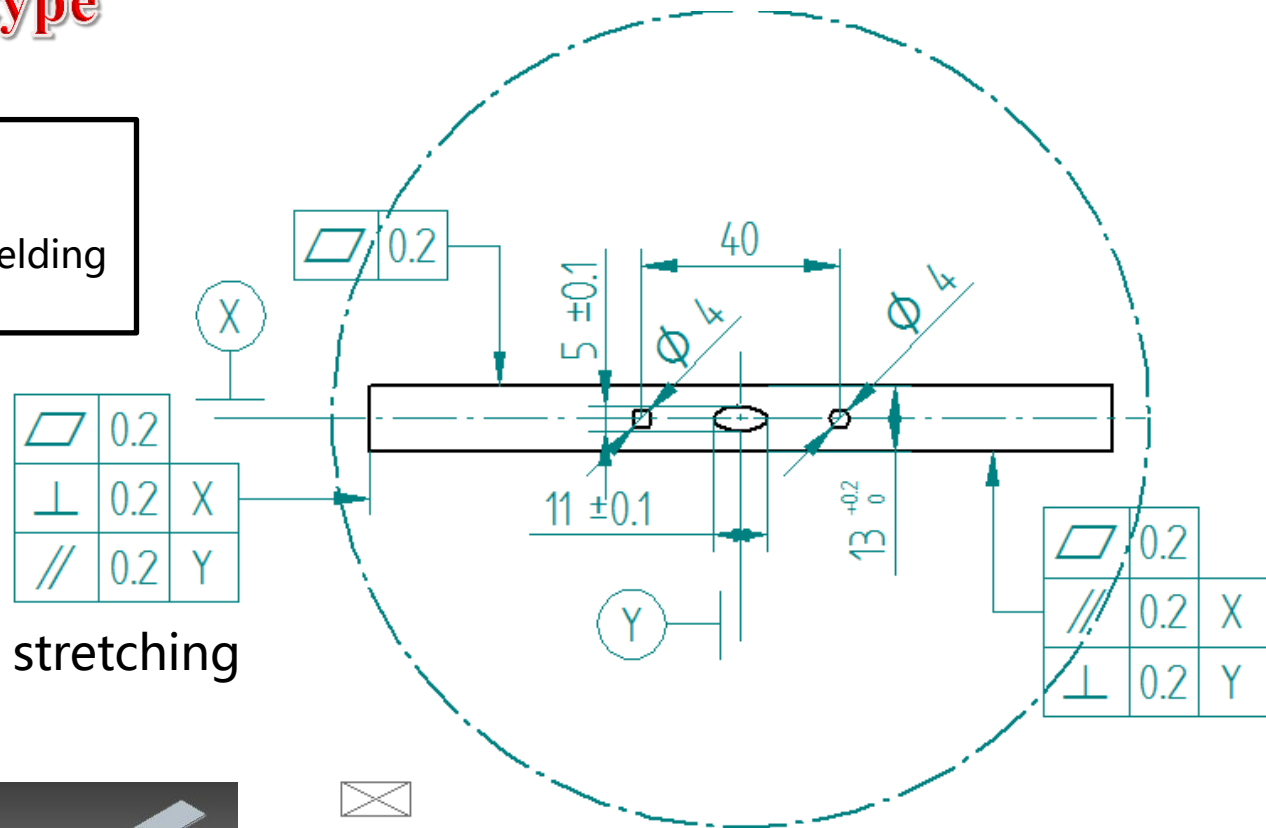
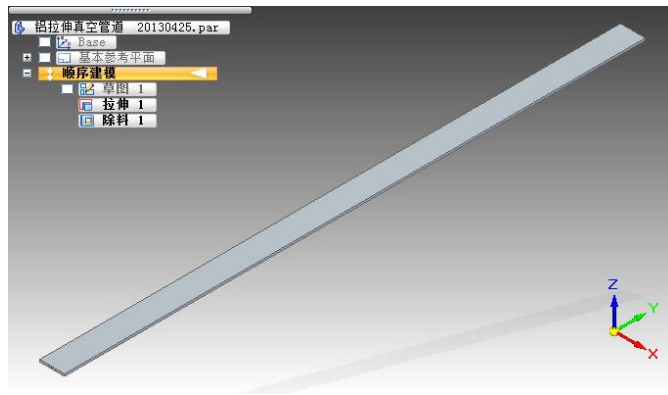
Undulator Chamber Prototype

Aluminum Prototype

Main points :

- 1、Tolerance
- 2、Enough Thickness for Welding
- 3、Cooling holes

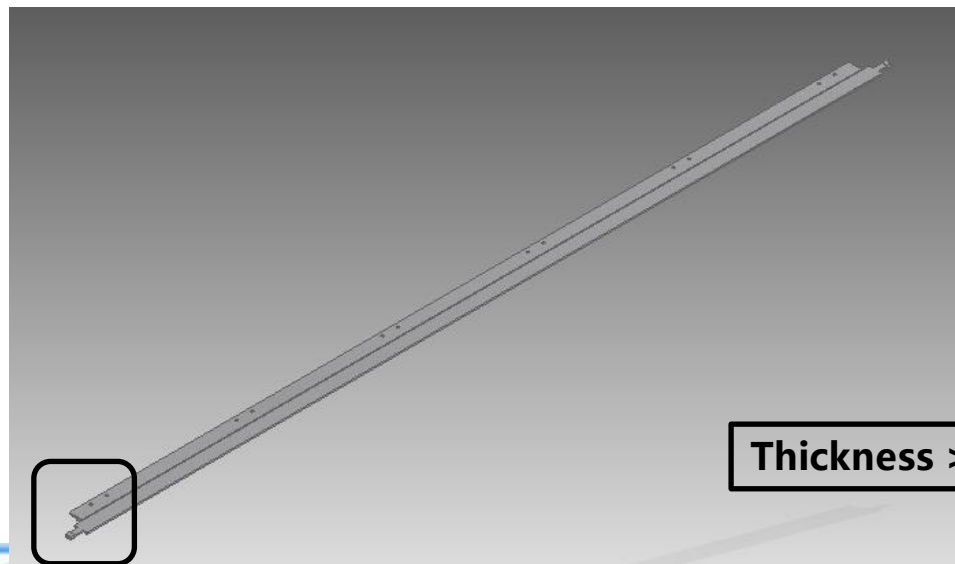
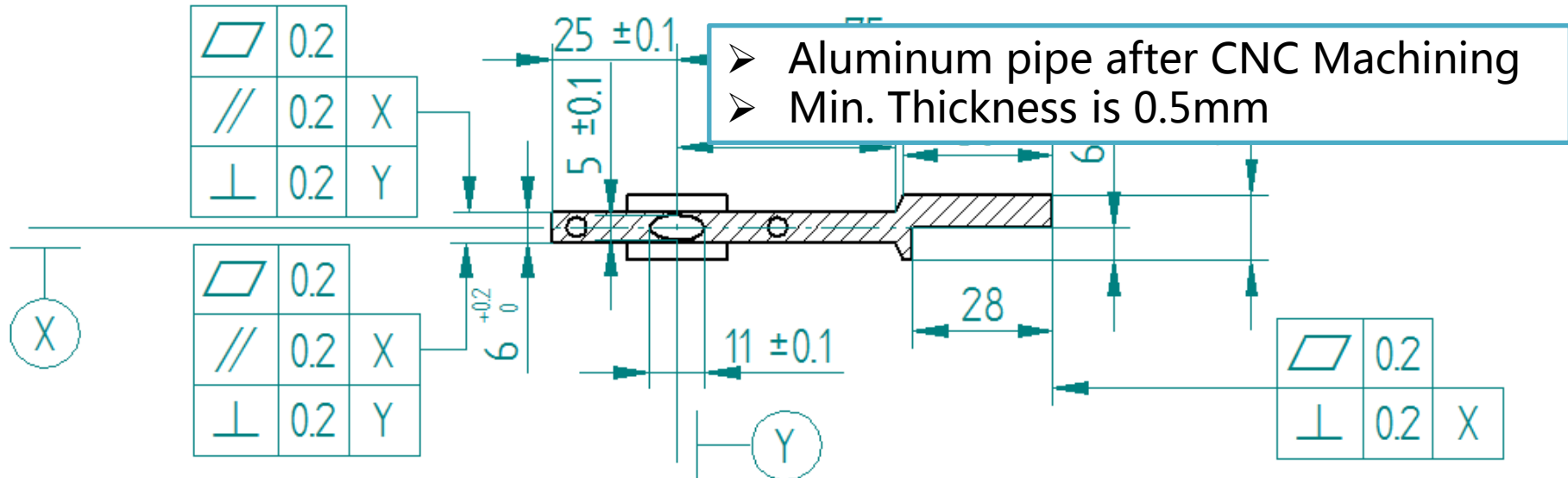
Aluminum pipe after stretching



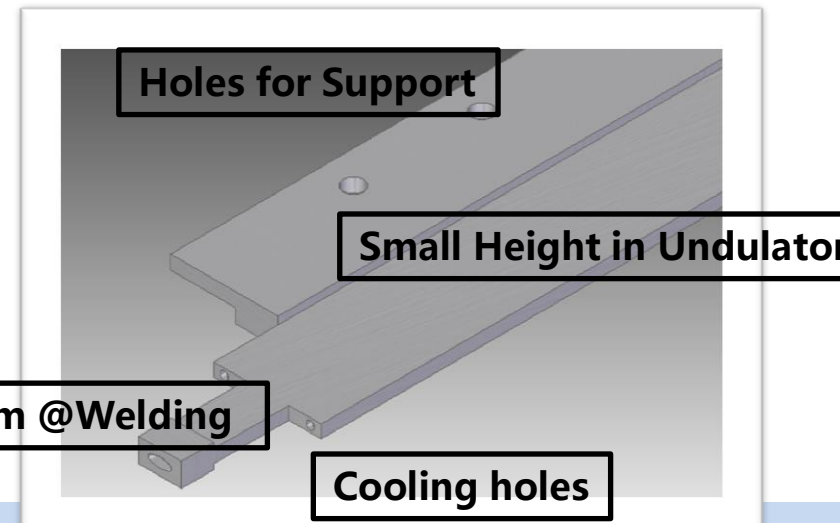
Height: 13mm
Aperture: 5mm×11mm

Undulator Chamber Prototype

Aluminum Prototype

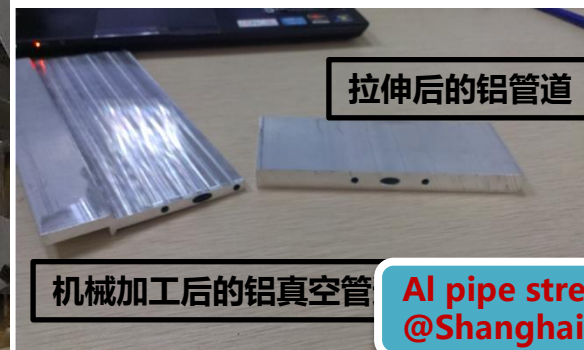


Thickness > 3mm @ Welding



Undulator Chamber Prototype

Aluminum Prototype



拉伸后的铝管道

机械加工后的铝真空管

Al pipe stretching
@Shanghai, China



Clad flanges
@Shanghai, China

Material	Al 6063
Inner aperture (mm ²)	5×11
Thickness (mm)	0.5
Length (m)	3.27



Al pipe CNC Machining
@Shanghai, China

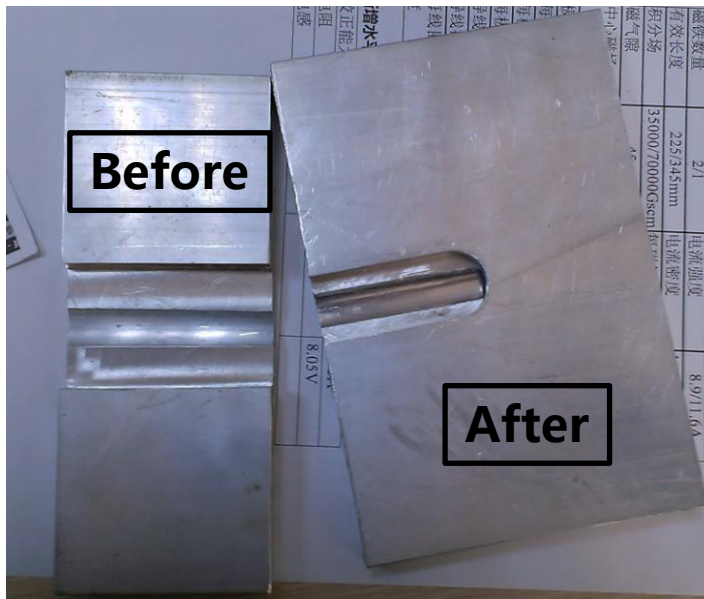


Inner Surface Polishing

- We use Abrasive Flow Polishing (AFP) method to polish the inner surface of the pipes.
- In AFP method, the high viscosity polishing fluid travels through the pipes to achieve the inner surface polishing



Copper Chamber Ra: 300nm~600nm



Ra—Al Chamber

Before	After
~200nm	~100nm



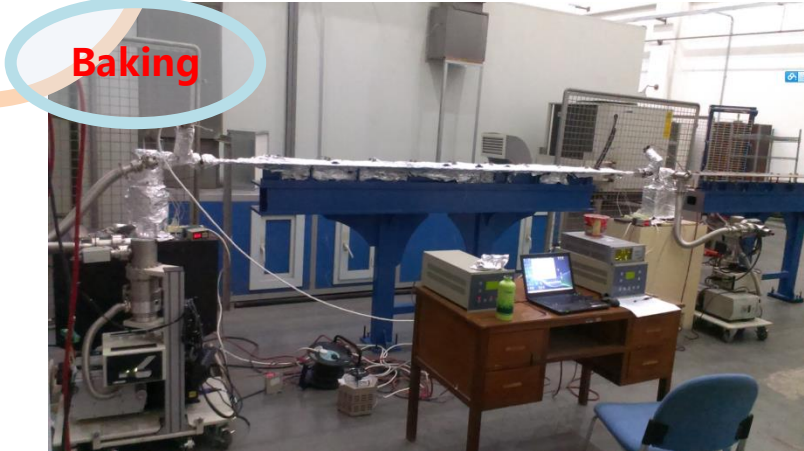
Vacuum Test



Installation

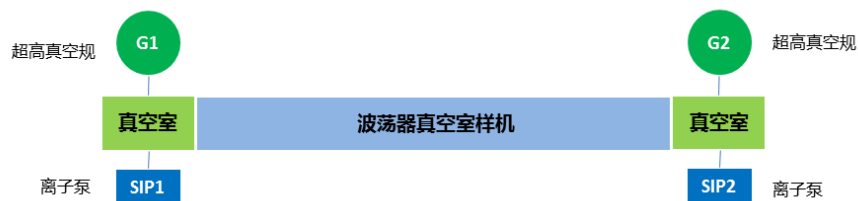
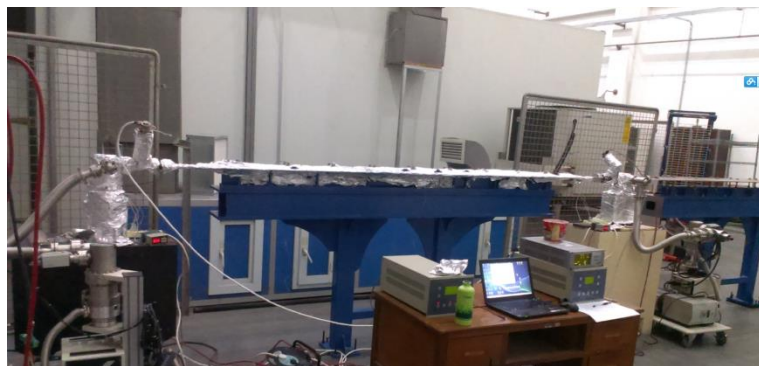


Leak



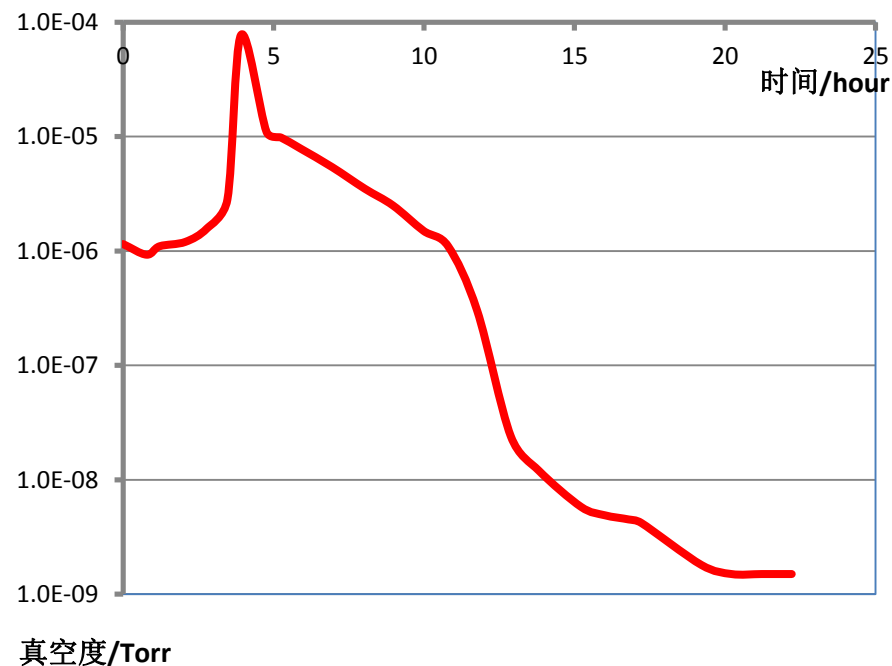
Baking

Vacuum Test



- 1、 Pressure is better than $2 \times 10^{-9} \text{ Torr}$
- 2、 Outgassing rate is very low

Pressure during baking



Vacuum Test



2



1

1#	2#	
Ion gauge (varian)	CCG (MKS)	
$4.6 \times 10^{-8} \text{ Torr}$	$6.2 \times 10^{-8} \text{ Torr}$	*
$1.4 \times 10^{-8} \text{ Torr}$	$4.0 \times 10^{-8} \text{ Torr}$	**

*10 hours after cool down form 6 hours 100°C baking

** 12 days after cool down

Summary

- Two prototype of undulator chamber have been developed for the upcoming FEL facilities.
- Inner surface polishing and vacuum testing have been done and satisfied the requirement
- Al-chamber will be used because of the cost

Thanks !